AD-A166 687 BIBLIOGRAPHY ON MULTI-COMPONENT DIFFUSION FOR MARINE APPLICATIONS-REFERENCES THROUGH 1984(U) NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY NSTL STATION MS.. 1/1

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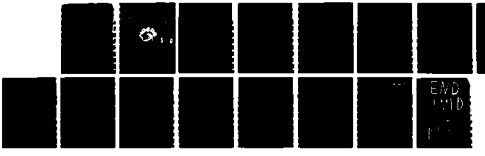

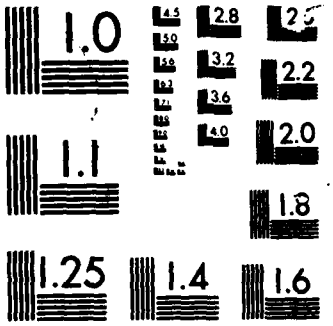

MICROCOPY CHART

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NSTL, Mississippi 39529

Bibliography on Multi-Component Diffusion for Marine Applications

References through 1984

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ABSTRACT

This report is a bibliography of over 230 published papers, reports, theses, and abstracts on double diffusion and multi-component diffusion through 1984. The citations cover research in oceanography, fluid mechanics, solar pond technology, and meteorology, with emphasis on the first two fields.

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INTRODUCTION

Complex convective instabilities can arise in fluids with two or more components when these components have different molecular diffusivities. When only two components are present, the process is termed double diffusive convection; when three or more, multicomponent convection. The existence of the phenomenon was first suggested in 1956 by three oceanographers, Stommel, Arons and Blanchard, but was considered only an "oceanographical curiosity" of little practical significance for a decade and a half. However, since the late 1960's it has become increasingly apparent that multicomponent convection is a very important process not only in oceanography but also in such diverse fields as astrophysics, metallurgy, chemical engineering, solid earth geophysics, and solar pond technology.

This bibliography was compiled in support of research in double diffusion by the Fine Scale Variability Project of the Physical Oceanography Branch at the Naval Ocean Research and Development Activity (NORDA). To limit its size, references from only the fields of oceanography, fluid mechanics, solar pond technology, and meteorology were included, with emphasis being placed on the first two categories. Excluded were citations from such fields as astrophysics, metallurgy, vulcanology, and other branches of geophysics. References through 1984 are presented; later years will be included in future versions. All citations are ordered alphabetically by first author and date, with co-authored papers following single author papers.

This document will be updated, annotated, and indexed in the future, and the author would appreciate being notified of any corrections or additions. Comments or requests for copies of this or future versions should be addressed to

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BIBLIOGRAPHICAL CITATIONS ON MULTI-COMPONENT DIFFUSION

Acheson, D.J. (1979). 'Stable' density stratification as a catalyst for instability. J. Fluid Mech., v. 96, p. 723-733.

Antoranz, J.C. and M.G. Velarde (1979). Thermal diffusion and convective stability: The role of uniform rotation of the container. Phys. Fluids, v. 22, p. 1038-1043.

Armi, L. and W. Zenk (1984). Large lenses of highly saline Mediterranean water. J. Phys. Ocean., v. 14, p. 1560-1576.

Baines, P.G. and A.E. Gill (1969). On thermohaline convection with linear gradients. J. Fluid Mech., v. 37, p. 289-306.

Baker, D.J., Jr. (1971). Density gradients in a rotating stratified fluid: Experimental evidence for a new instability. Science, v. 172, p. 1029-1031.

Bergman, T.L., F.P. Incropera, and R. Viskanta (1982). A multi-layer model for mixing layer development in a double-diffusive thermohaline system heated from below. Int. J. Heat and Mass Transfer, v. 25, p. 1411-1418.

Boyd, J.D. and H.T. Perkins (1984). Estimates of vertical heat and salt fluxes in a thermohaline staircase. EOS, v. 65, p. 954.

Boyd, J.D., H.T. Perkins, and K.D. Saunders (1983). Characteristics of thermohaline step structures off the northeast coast of South America. EOS, v. 64, p. 1058.

Broughton, J.M. (1972). Experiments on steady layered convection in a doubly diffusive system. Masters thesis, Colorado State University, Fort Collins, Colorado.

Bruce, J.G., J.L. Kerling, and W.H. Beatty III (1984). Temperature steps off Northern Brazil. Tropical Ocean-Atmosphere Newsletter, n. 23, January, p. 10-11.

Caldwell, D.R. (1973). Thermal and Fickian diffusion of sodium chloride in a solution of oceanic concentration. Deep-Sea Res., v. 20, p. 1029-1039.

Caldwell, D.R. (1983). Small-scale physics of the ocean. U.S. Nat'l Report to the Int'l Union of Geodesy and Geophysics 1979-1982. Reviews of Geophysics and Space Physics, v. 21, p. 1192-1205.

Calman, J. (1977). Experiments on high Richardson number instability of a rotating stratified shear flow. Dyn. Atmos. Oceans, v. 1, p. 277-297.

Carmack, E. and K. Aagaard (1973). On the deep water of the Greenland Sea. Deep-Sea Res., v. 20, p. 687-715.

Chen. C.F. (1974). Onset of cellular convection in a salinity gradient due to a lateral temperature gradient. J. Fluid Mech., v. 63, p. 563-576.

Chen, C.F. (1975). Double-diffusive convection in an inclined slot. J. Fluid Mech., v. 72, p. 721-729.

Chen, C.F. (1978). Time-dependent double-diffusive instability in a density-stratified fluid along a heated inclined wall. J. Heat Transfer, v. 100, p. 653-658.

Chen, C.F., D.G. Briggs, and R.A. Wirtz (1971). Stability of thermal convection in a salinity gradient due to lateral heating. Int. J. Heat and Mass Transfer, v. 14, p. 57-65.

Chen, C.F. and W.W. Skok (1974). Cellular convection in a salinity gradient along a heated inclined wall. Intl. J. Heat Mass Transfer, v. 17, p. 51-60.

Chen, C.F. and S.B. Wong (1974). Double-diffusive convection along a sloping wall. Bull. Am. Phys. Soc., v. 19, p. 1153.

Chen, C.F., R.C. Paliwal, and S.B. Wong (1976). Cellular convection in a density stratified fluid: Effect of inclination of the heated wall. Proc. 1976 Heat Transfer and Fluid Mech. Institute, Stanford U. Press, Palo Alto, CA, p. 18-32.

Chen, C.F. and R.D. Sandford (1976). Size and shapes of salt fingers near marginal state. J. Fluid Mech., v. 78, p. 601-607.

Chen, C.F. and R.D. Sandford (1977). Stability of time-dependent double diffusive convection in an inclined slot. J. Fluid Mech., v. 83, p. 83-95.

Chen, C.F. and D.H. Johnson (1984). Double-diffusive convection: A report on an Engineering Foundation conference. J. Fluid Mech., v. 138, p. 405-416.

Cooper, J.W. and H. Stommel (1968). Regularly spaced steps in the main thermocline near Bermuda. J. Geophys. Res., v. 73, p. 5849-5854.

Cortecci, G., R. Molcard, and P. Noto (1974). Isotopic analysis of the deep staircase structure in the Tyrrhenian Sea. Nature, v. 250, p. 134-136.

Crapper, P.F. (1975). Measurements across a diffusive interface. Deep-Sea Res. v. 22, p. 537-545.

Da Costa, L.N., E. Knobloch, and N.O. Weiss (1981). Oscillations in double-diffusive convection. J. Fluid Mech., v. 109, p. 25-43.

Degens, E.T. and D.A. Ross, eds (1969). Hot Brines and Recent Heavy Metal Deposits in the Red Sea. Springer-Verlag New York, 599 p.

Delnore, V.E. (1980). Numerical simulation of thermohaline convection in the upper ocean. J. Fluid Mech., v. 93, p. 803-826.

Delnore, V.E. and J. McHugh (1972). BOMEX Period III Upper Ocean Soundings. National Oceanic and Atmospheric Administration/Center for Experimental Design and Data Analysis, Rockville, MD, 352 p.

Demenkow, J.W. (1973). A study of the two layer salt finger system. PhD dissertation, U. of Rhode Island, Kingston, RI.

Elder, J.W. (1969). Numerical experiments with thermohaline convection. Phys. Fluids, v. 12, Suppl. II, p. 194-197.

Elliot, A.J., M.R. Howe, and R.I. Tait (1974). The lateral coherence of a system of thermohaline layers in the deep ocean. Deep-Sea Res., v. 21, p. 95-107.

Elliot, A.J. and R.I. Tait (1977). On the steady-state nature of the Mediterranean Outflow step structure. A Voyage of Discovery, G. Deacon 70th Anniversary Volume, Suppl. to Deep-Sea Res., p. 213-220.

Escowitz, E.C. and A.F. Amos (1971). Steps on the thermocline northeast of Barbados Trans. Am. Geophys. Union, v. 52, p. 232.

Evans, David L. (1981). Velocity shear in a thermohaline staircase. Deep-Sea Res., v. 28, p. 1409-1415.

Fedorov, K.N. (1980). Intrusive fine structure in frontal zones and indication of double diffusion. In: J. Nihoul, ed. Marine Turbulence. Elsevier, New York, p. 57-63.

Foster, T.D. and E.C. Carmack (1976). Temperature and salinity structure in the Weddell Sea. J. Phys. Ocean., v. 6, p. 36-44.

Gargett, A.E. (1976). An investigation of the occurrence of oceanic turbulence with respect to fine structure. J. Phys. Ocean., v. 6, p. 139-159.

Gargett, A.E. and R.W. Schmitt (1982). Observations of salt fingers in the Central Waters of the Eastern North Pacific. J. Geophys. Res., v. 87, p. 8017-8029.

Garrett, C. (1982). On the parameterization of diapycnal fluxes due to double-diffusive intrusions. J. Phys. Ocean., v. 12, p. 952-959.

Gill, A.E. and J.S. Turner (1969). Some new ideas about the formation of Antarctic Bottom Water. Nature, v. 224, p. 1287-1288.

Gordon, A.L. (1981). South Atlantic thermocline ventilation. Deep-Sea Res., v. 28, p. 1236-1264.

Gough, D.O. and J. Toomre (1982). Single-mode theory of diffusive layers in thermohaline convection. J. Fluid Mech., v. 125, p. 75-97.

Green, T. (1984). Scales for double-diffusive fingering in porous media. Water Resources Res., v. 20, p. 1225-1229.

Gregg, M.C. (1975). Microstructure and intrusions in the California Current. J. Phys. Ocean., p. 5, p. 253-278.

Gregg, M.C. (1980a). Microstructure patches in the thermocline. J. Phys. Ocean., v. 10, p. 915-943.

Gregg, M.C. (1980b). The three-dimensional mapping of a small thermohaline intrusion. J. Phys. Ocean., v. 10, p. 1468-1492.

Gregg, M.C. and C.S. Cox (1972). The vertical microstructure of temperature and salinity. Deep-Sea Res., v. 19, p. 355-376.

Gregg, M.C. and J.H. McKenzie (1979). Thermohaline intrusions lie across isopycnals. Nature, v. 280, p. 310-311.

Gregg, M.C. and T.B. Sanford (1980). Signatures of mixing from the Bermuda Slope, the Sargasso Sea and the Gulf Stream. J. Phys. Ocean., v. 10, p. 105-127.

Griffiths, R.W. (1979a). The transport of multiple components through thermohaline diffusive interfaces. Deep-Sea Res., v. 26, p. 383-397.

Griffiths, R.W. (1979b). The influence of a third diffusing component upon the onset of convection. J. Fluid Mech., v. 92, p. 659-670.

Griffiths, R.W. (1979c). A note on the formation of 'salt-finger' and 'diffusive' interfaces in three-component systems. Int. J. Heat and Mass Transfer, v. 22, p. 1687-1693.

Griffiths, R.W. (1979d). Transports through thermohaline interfaces in a viscous fluid and a porous medium. PhD dissertation, Australian National University, Canberra.

Griffiths, R.W. (1981). Layered double-diffusive convection in porous media. J. Fluid Mech., v. 102, p. 221-248.

Griffiths, R.W. and B.R. Ruddick (1980). Accurate fluxes across a salt-sugar interface deduced from direct density measurements. J. Fluid Mech., v. 99, p. 85-95.

Groves, G.W. (1959). Flow estimate for the perpetual salt fountain. Deep-Sea Res., v. 5, p. 209-214.

Herman, A.W. and K.L. Denman (1979). Intrusions and vertical mixing at the shelf/slope water front south of Nova Scotia. J. Fish. Res. Bd. Canada, v. 36, p. 1445-1453.

Hart, J.E. (1970). Thermal convection between sloping parallel boundaries. PhD dissertation, Mass. Inst. of Tech., Cambridge, MA.

Hart, J.E. (1971a). Stability of the flow in a differentially heated inclined box. J. Fluid Mech., v. 47, p. 547-576.

Hart, J.E. (1971b). On sideways diffusive instability. J. Fluid Mech., v. 49, p. 279-288.

Hart, J.E. (1973). Finite amplitude sideways diffusive convection. J. Fluid Mech., v. 59, p. 47-64.

Heinrich, J.C. (1984). A finite element model for double diffusive convection. Int. J. Num. Methods Engin., v. 20,p. 447-464.

Hoare, R.A. (1966). Problems of heat transfer in Lake Vanda. Nature, v. 210, p. 787-769.

Hoare, R.A. (1968). Thermohaline convection in Lake Vanda, Antarctica. J. Geophys. Res., v. 73, p. 607-612.

Holyer, J.Y. (1981). On the collective instability of salt fingers. J. Fluid Mech., v. 110, p. 195-207.

Holyer, J.Y. (1983). Double-diffusive interleaving due to horizontal gradients. J. Fluid Mech., v. 137, p. 347-362.

Holyer, J.Y. (1984). The stability of long, steady, two-dimensional salt fingers. J. Fluid Mech., v. 147, p. 169-185.

Horne, E.P.W. (1978). Interleaving at the subsurface front in the slope water off Novia Scotia. J. Geophys. Res., v. 83, p. 3659-3671.

Howe, M.R. and R.I. Tait (1970). Further observations of thermohaline stratification in the deep ocean. Deep-Sea Res., v. 17, p. 963-972.

Hsu, Y.S. (1974). Double diffusive instabilities with and without a weak vertical shear. PhD dissertation, Harvard University, Cambridge, MA.

Huppert, H.E. (1971). On the stability of a series of double-diffusive layers. Deep-Sea Res., v. 18, p. 1005-1021.

Huppert, H.E. (1976). Transitions in double-diffusive convection. Nature, v. 263, p. 20-22.

Huppert, H.E. (1983). Multicomponent convection: turbulence in earth, sun and sea. Nature, v. 303, p. 478-479.

Huppert, H.E. and J.S. Turner (1972). Double-diffusive convection and its implications for the temperature and salinity structure of the ocean and Lake Vanda. J. Phys. Ocean., v. 2, p. 456-461.

Huppert, H.E. and P.C. Manins (1973). Limiting conditions for salt fingering at an interface. Deep-Sea Res., v. 20, p. 315-323.

Huppert, H.E. and P.F. Linden (1976). The spectral signature of salt fingers. Deep-Sea Res., v. 23, p. 909-914.

Huppert, H.E. and D.R. Moore (1976). Nonlinear double-diffusive convection. J. Fluid Mech., v. 78, p. 821-854.

Huppert, H.E. and J.S. Turner (1978). On melting icebergs. Nature, v. 271, p. 46-48.

Huppert, H.E. and J.S. Turner (1980). Ice blocks melting into a salinity gradient. J. Fluid Mech., v. 100, p. 367-384.

Huppert, H.E. and E.G. Josberger (1980). The melting of ice in cold stratified water. J. Phys. Ocean., v. 10, p. 953-960.

Huppert, H.E. and J.S. Turner (1981). Double diffusive convection. J. Fluid Mech., v. 106, p. 299-329.

Johannessen, O.M. and O.S. Lee (1974). A deep stepped thermohaline structure in the Mediterranean. Deep-Sea Res., v. 21, p. 629-639.

Joyce, T.M. (1977). A note on the lateral mixing of water masses. J. Phys. Oceanogr., v. 7, p. 626-629.

Joyce, T.M. (1982). Salt fingers: Limits to growth. J. Mar. Res., v. 40 (suppl.), p. 291-306.

Joyce, T.M., W. Zenk, and J.M. Toole (1978). The anatomy of the Antarctic Polar Front in the Drake Passage. J. Geophys. Res., v. 83, p. 6093-6113.

Kaviany, M. (1984). Effect of a stabilizing solute gradient on the onset of thermal convection. Phys. Fluids, v. 27, p. 1108-1113.

Kelley, D. (1984). Effective diffusivities within oceanic thermohaline staircases. J. Geophys. Res., v. 89, p. 10,484-10,488.

Kerr, R.A. (1981). Fingers of salt help mix the sea. Science, v. 211, p. 155-157.

Knobloch, E. and M.R.E. Proctor (1981). Nonlinear periodic convection in double-diffusive systems. J. Fluid Mech., v. 108, p. 291-316.

Lambert, R.B. (1971). Experimental studies of stratified layers. In: Proc. of the Joint Oceanographic Assembly, Tokyo, 1970, p. 199-200.

Lambert, R.B. and J.W. Demenkow. (1972). On the vertical transport due to fingers in double diffusive convection. J. Fluid Mech., v. 54, p. 627-640.

Lambert, R.B. and D.L. Evans (1974). A confined thermohaline staircase. EOS, Trans. Am. Geophys. Union, v. 55, p. 296.

Lambert, R.B., Jr., and W. Sturges (1977). A thermohaline staircase and vertical mixing in the thermocline. Deep-Sea Res., v. 24, p. 211-222.

Larson, N.G. and M.C. Gregg (1983). Turbulent dissipation and shear in thermohaline intrusions. Nature, v. 306, p. 26-32.

Lee, S.I. (1983). Density structure associated with salt fingers. Master's thesis, Naval Postgraduate School, Monterey, CA.

Lewis, W.T., F.P. Incropera, and R. Viskanta (1982). Interferometric study of stable salinity gradients heated from below or cooled from above. J. Fluid Mech., v. 116, p. 411-430.

Linden, P.F. (1971). Salt fingers in the presence of grid-generated turbulence. J. Fluid Mech., v. 49, p. 611-624.

Linden, P.F. (1974b). A note on the transport across a diffusive interface. Deep-Sea Res., v. 21, p. 283-287.

Linden, P.F. (1976). The formation and destruction of finestructure by double-diffusive processes. Deep-Sea Res., v. 23, p. 895-908.

Linden, P.F. (1978). The formation of banded salt finger structure. J. Geophys. Res., v. 83, p. 2902-2912.

Linden, P.F. and J.E. Weber (1977). The formation of layers in a double diffusive system with a sloping boundary. J. Fluid Mech., v. 81, p. 757-773.

Linden, P.F. and T.G.L. Shirtcliffe (1978). The diffusive interface in double-diffusive convection. J. Fluid Mech., v. 87, p. 417-432.

McDougall, T.J. (1981a). Double diffusive convection with a non-linear equation of state. Part I: The accurate conservation of properties in a 2-layer system. Prog. Ocean., v. 10, p. 71-89.

McDougall, T.J. (1981b). Double diffusive convection with a nonlinear equation of state. Part II: Laboratory experiments and their interpretation. Prog. Ocean., v. 10, p. 91-121.

McDougall, T.J. (1981c). Fluxes of properties through a series of double-diffusive interfaces with a nonlinear equation of state. J. Phys. Ocean., v. 11, p. 1294-1299.

McDougall, T.J. (1983). Double-diffusive convection caused by coupled molecular diffusion. J. Fluid Mech., v. 126, p. 379-397.

McDougall, T.J. (1983). Double-diffusive plumes in unconfined and confined environments. J. Fluid Mech., v. 133, p. 321-343.

McDougall, T.J. (1983). Greenland Sea Bottom Water formation: a balance between advection and double-diffusion. Deep-Sea Res., v. 30, p. 1109-1118.

McDougall, T.J. (1984a). Fluid dynamic implications for massive sulphide deposits of hot saline fluid flowing into a submarine depression from below. Deep-Sea Res., v. 31, p. 145-170.

McDougall, T.J. (1984b). Convective processes caused by a dense, hot saline source flowing into a submarine depression from above. Deep-Sea Res., v. 31, p. 1287-1309.

McDougall, T.J. and B.R. Ruddick (1982). The effects on fine structure measurements of correcting for internal wave strain. J. Phys. Ocean., v. 12, p. 495-497.

McDougall, T.J. and J.S. Turner (1982). Influence of cross-diffusion on "finger" double-diffusive convection. Nature, v. 299, p. 812-814.

McDougall, T.J. and J.R. Taylor (1984). Flux measurements across a finger interface at low values of the stability ratio. J. Mar. Res., v. 42, p. 1-14.

McDougall, T.J. and J.A. Whitehead, Jr. (1984). Estimates of the relative roles of diapycnal, isopycnal and double-diffusive mixing in Antarctic Bottom Water in the North Atlantic. J. Geophys. Res., v. 89, p. 10,479-10,483.

McIntyre, M.E. (1970). Diffusive destabilization of the baroclinic vortex. Geophys. Fluid Dyn., v. 1, p. 19-57.

Mack, S.A., D.C. Wenstrand, J. Calman, and R.C. Burkhardt (1982). Characteristics of thermal microstructure in the ocean. Johns Hopkins APL Technical Digest, v. 3, no. 1, p. 28-35.

Magnell, B. (1976). Salt fingers observed in the Mediterranean outflow region (34°N, 11°W) using a towed sensor. J. Phys. Ocean., v. 6, p. 511-523.

Marmorino, G.O. (1974). Equilibrium heat and salt transport through a diffusive thermohaline interface. Master's thesis, Oregon State University, Corvallis, Oregon.

Marmorino, G.O. and D.R. Caldwell (1976). Heat and salt transport through a diffusive thermohaline interface. Deep-Sea Res., v. 23, p. 59-67.

Marmorino, G.O. and D.R. Caldwell (1978). Temperature finestructure and microstructure observations in a coastal upwelling region during a period of variable winds (Oregon, summer 1974). Deep-Sea Res., v. 25, p. 1073-1106.

Maslowe, S.A. (1985). Direct resonance in double-diffusive systems. Studies in Applied Mathematics, v. 73, p. 59-74.

Masuda, A. (1978). Double diffusive convection in a rotating system. J. Oceanogr. Soc. Japan, v. 34, 8-16.

Maxworthy, T. (1983). The dynamics of double-diffusive gravity currents. J. Fluid Mech., v. 128, p. 259-282.

Mazeika, P.A. (1974). Subsurface mixed layers in the northwest tropical Atlantic. J. Phys. Ocean., v. 4, p. 446-453.

Mellberg, L.E., O.M. Johannessen, and O.S. Lee (1974). Acoustic effect caused by a deep thermohaline stepped structure in the Mediterranean Sea. J. Acoust. Soc. Am., v. 55, p. 1081-1083.

Merceret, F.J. (1977). A possible manifestation of double diffusive convection in the atmosphere. Boundary-Layer Met., v. 11, p. 121-123.

Middleton, J.H. and T.P. Foster (1980). Finestructure measurements in a temperature compensated halocline. J. Geophys. Res. v. 85, p. 1107-1122.

Miller, R.R. and D.G. Browning (1974). Thermal layering between the Galapagos Islands and South America. Deep-Sea Res., v. 21, p. 669-673.

Molcard, R. and A.J. Williams (1975). Deep step structure in the Tyrrhenian Sea. Memoires de la Societe Royale des Sciences de Liege 6eme Serie, v. 7, p. 191-210.

Molcard, R. and R.I. Tait (1977). The steady state of the step structure in the Tyrrhenian Sea. In: M. Angel, ed. A Voyage of Discovery: George Deacon Seventieth Anniversary Volume. Pergamon Press, New York, p. 221-233.

Moore, D.W. and E.A. Spiegel (1966). A thermally excited non-linear oscillator. Astrophys. J., v. 143, p. 871-887.

Moore, D.R., J. Toomre, E. Knobloch, and N.O. Weiss (1983). Period doubling and chaos in partial differential equations for thermosolutal convection. Nature, v. 303, p. 663-667.

Neshyba, S., V.T. Neal, and W. Denner (1971a). Temperature and conductivity measurements under Ice Island T3. J. Geophys. Res., v. 76, p. 8107-8120.

Neshyba, S., V.T. Neal, and W. Denner (1971b). Internal waves and thermo-solutal microstructure, Proc. 8th U.S. Navy Symp. Mil. Oceanogr., 1, 341-348.

Neshyba, S., V.T. Neal, and W.W. Denner (1972). Spectra of internal waves: In situ measurements in a multiple-layered structure. J. Phys. Ocean., v. 2, p. 91-95.

Neuymin, G.G. and V.A. Urdenko (1979). Possible effects of "salt fingers" on measurements of the transparency of ocean waters. Oceanol., v. 19, p. 23-26.

Newell, T.A. and R.F. Boehm (1982). Gradient zone constraints in a salt-stratified solar pond. Trans. ASME: J. Solar Pond Engng, v. 104, p. 280-285.

Newell, T.A. (1984). Characteristics of a double-diffusive interface at high density stability ratios. J. Fluid Mech., v. 149, p. 385-401.

Newman, F.C. (1976). Temperature steps in Lake Kivu: a bottom heated saline lake. J. Phys. Ocean., v. 6, p. 157-163.

Nield, D.A. (1967). The thermohaline Rayleigh-Jeffreys problem. J. Fluid Mech., v. 19, p. 545-558.

Oakey, N.S. and J.A. Elliott (1980). Variability of temperature gradient microstructure observed in the Denmark Strait. J. Geophys. Res., v. 85, p. 1933-1944.

Osborn, T.R. (1973). Temperature microstructure in Powell Lake. J. Phys. Ocean., v. 3, p. 302-307.

Ozmidov, R.V. (1982). The third voyage of the scientific R/V AKADEMIK MSTISLAV KELDYSH. Oceanology, v. 22, p. 504-506.

Paliwal, R.C. (1979). Double-diffusive convective instability in an inclined fluid layer. PhD dissertation, Department of Mechanical, Industrial and Aerospace Engineering, Rutgers University, New Brunswick, NJ.

Paliwal, R.C. and C.F. Chen (1980). Double-diffusive instability in an inclined fluid layer. Part 1. Experimental investigation. J. Fluid Mech., v. 98, p. 755-768.

Paliwal, R.C. and C.F. Chen (1980). Double-diffusive instability in an inclined fluid layer. Part 2. Stability analysis. J. Fluid Mech., v. 98, p. 769-785.

Pearlstein, Arne J. (1981). Effect of rotation on the stability of a doubly diffusive layer. J. Fluid Mech., v. 103, p. 389-412.

Perkin, R.G., and E.L. Lewis (1984). Mixing in the West Spitsbergen Current. J. Phys. Ocean., v. 14, p. 1315-1325.

Perkins, H. and K. Saunders (1982). Physical oceanographic observations in the northwest tropical Atlantic. Tropical Ocean-Atmosphere Newsletter, September, p. 7-9.

Piacsek, S.A. and J. Toomre (1980). Nonlinear evolution and structure of salt fingers. In: J.C.J. Nihoul, ed. Marine Turbulence. Elsevier, New York, p. 193-219.

Poplawsky, C.J., F.P. Incropera, and R. Viskanta (1981). Mixed layer development in a double-diffusive, thermohaline system. Trans. ASME: J. Solar Pond Engng., v. 103, p. 351-359.

Pingree, R.D. (1969). Small-scale structure of temperature and salinity near Station Cavall. Deep-Sea Res., v. 16, p. 275-295.

Posmentier, E.S. and R.W. Houghton (1978). Fine structure instabilities induced by double diffusion in the shelf/slope water front. J. Geophys. Res., v. 83, p. 5135-5138.

Posmentier, E.S. and C.B. Hibbard (1982). The role of tilt in double diffusive interleaving. J. Geophys. Res., v. 87, p. 518-524.

Proctor, M.R.E. (1981). Steady subcritical thermohaline convection. J. Fluid Mech., v. 105, p. 507-521.

Reddy, C.S. (1978). Double-diffusive convection in an infinitely tall slot - a numerical study. Am. Soc. Mech. Engrs., ASME paper No. 78-WA/HT-8, 8 p.

Ruddick, B.R. and J.S. Turner (1979). The vertical scale of double diffusive intrusions. Deep-Sea Res., v. 26, p. 903-913.

Ruddick, B.R. and T.G.L. Shirtcliffe (1979). Data for double diffusers: Physical properties of aqueous salt-sugar solutions. Deep-Sea Res., v. 26, p. 775-787.

Ruddick, B. (1983). A practical indicator of the stability of the water column to double-diffusive activity. Deep-Sea Res., v. 30, p. 1105-1107.

Ruddick, B. (1984). The life of a thermohaline intrusion. J. Mar. Res., v. 42, p. 831-852.

Salusti, E. (1978). Internal waves on a deep-stepped marine structure. Deep-Sea Res., v. 25, p. 947-956.

Sarsten, J.A. (1972). LNG stratification and roll-over. Pipeline and Gas J., v. 199, p. 37-39.

Schmitt, R.W. (1976). On the flux ratio of salt fingers. EOS, Trans. Am. Geophys. Union, v. 57, p. 261.

Schmitt, R.W. (1979a). Flux measurements on salt fingers at an interface. J. Mar. Res., v. 37, p. 419-436.

Schmitt, R.W. (1979b). The growth rate of supercritical salt fingers. Deep-Sea Res., v. 26, p. 23-40.

Schmitt, R.W. (1981). Form of the temperature-salinity relationship in the Central Water: evidence for double-diffusive mixing. J. Phys. Ocean., v. 11, p. 1015-1026.

Schmitt, R.W. (1983). The characteristics of salt fingers in a variety of fluid systems, including stellar interiors, liquid metals, oceans, and magmas. Phys. Fluids, v. 26, p. 2373-2377.

Schmitt, R.W. and D.L. Evans (1978). An estimate of the vertical mixing due to salt fingers based on observations in the North Atlantic Central Water. J. Geophys. Res., v. 83, p. 2913-2919.

Schmitt, R.W. and R.B. Lambert (1979). The effect of rotation on salt fingers. J. Fluid Mech., v. 90, p. 449-463.

Schmitt, R.W. and D.T. Georgi (1982). Finestructure and microstructure in the North Atlantic Current. J. Mar. Res., v. 40 (suppl.), p. 659-705.

Sherman, F.S., J. Imberger, and G.M. Corcos (1978). Turbulence and mixing in stably stratified waters. Ann. Rev. Fluid Mech., v. 10, p. 267-282.

Shirtcliffe, T.G.L. (1967). Thermosolutal convection: observation of an overstable mode. Nature, v. 213, p. 489-490.

Shirtcliffe, T.G.L. (1969). The development of layered thermosolutal convection. Intl. J. Heat Mass Transfer, v. 12, p. 215-222.

Shirtcliffe, T.G.L. (1972). The contribution of double-diffusive processes to the vertical fluxes of salt and heat. In: R. Fraser, ed. Oceanography of the South Pacific. New Zealand Comm. for UNESCO, Wellington (New Zealand), p. 137-139.

Shirtcliffe, T.G.L. (1973). Transport and profile measurements of the diffusive interface in double-diffusive convection with similar diffusivities. J. Fluid Mech., v. 57, p. 27-43.

Shirtcliffe, T.G.L. and I.M. Calhaem (1968). Measurements of temperature and electrical conductivity in Lake Vanda, Victoria Land, Antarctica. N. Z. J. Geol. Geophys., v. 11, p. 976-981.

Shirtcliffe, T.G.L. and J.S Turner (1970). Observations of the cell structure of salt fingers. J. Fluid Mech., v. 41, p. 707-719.

Siedler, G. and W. Zenk (1973). Variability of the thermohaline staircase. Nature Physical Science, v. 244, n. 131, p. 11-12.

Siegmann, W.L. and L.A. Rubenfeld (1975). A nonlinear model for double-diffusive convection. SIAM J. Applied Math., v. 29, p. 540-557.

Simpson, J.H., M.R. Howe, N.C.G. Morris, and J. Stratford (1979). Velocity shear in the steps below the Mediterranean outflow. Deep-Sea Res., v. 26, p. 1381-1386.

Stern, M.E. (1960). The 'salt-fountain' and thermohaline convection. Tellus, v. 12, p. 172-175.

Stern, M.E. (1967). Lateral mixing of water masses. Deep-Sea Res., v. 14, p. 747-753.

Stern, M.E. (1968). T, S gradients in the micro-scale. Deep-Sea Res., v. 15, p. 245-250.

Stern, M.E. (1969a). Collective instability of salt fingers. J. Fluid Mech., v. 35., p. 209-218.

Stern, M.E. (1969b). Salt finger convection and the energetics of the general circulation. Deep-Sea Res., v. 16 (Suppl.), p. 263-267.

Stern, M.E. (1975). Ocean Circulation Physics. Academic Press, New York, p. 189-215.

Stern, M.E. (1976). Maximum buoyancy flux across a salt finger interface. J. Mar. Res., v. 34, p. 95-110.

Stern, M.E. (1982). Inequalities and variational principles in d ɔle-diffusive turbulence. J. Fluid Mech., v. 114, p. 105-121.

Stern, M.E. and J.S. Turner (1969). Salt fingers and convecting layers. Deep-Sea Res., v. 16, p. 497-511.

Stommel, H., A.B. Arons, and D. Blanchard (1956). An oceanographical curiosity: the perpetual salt fountain. Deep-Sea Res., v. 3, p. 152-153.

Stommel, H. and K.N. Fedorov (1967). Small-scale structure in temperature and salinity near Timor and Mindanao. Tellus, v. 19, p. 306-325.

Straus, J.M. (1972). Finite amplitude doubly-diffusive convection. J. Fluid Mech., v. 56, p. 353-374.

Tait, R I. and M.R. Howe (1968) Some observations of the thermohaline stratification in the deep ocean. Deep-Sea Res., v. 15, p. 275-280.

Tait, R.I. and M.R. Howe (1971). Thermohaline staircase. Nature, v. 231, p. 178-179.

Taunton, J.W., E.N. Lightfoot, and T. Green (1972). Thermohaline instability and salt fingers in a porous medium. Phys. Fluids, v. 15, p. 748-753.

Thangam, S., A. Zebib, and C.F. Chen (1982). Double-diffusive convection in an inclined fluid layer. J. Fluid Mech., v. 116, p. 363-378.

Thangam, S., A. Zebib, and C.F. Chen (1984). Salt-finger convection in shear flow. Phys. Fluids, v. 27, p. 804-811.

Thorpe, S.A., P.K. Hutt, and R.J. Soulsby (1969). The effect of horizontal gradients on thermohaline convection. J. Fluid Mech., v. 38, p. 375-400.

Toole, J.M. (1981). Intrusion characteristics in the Antarctic Polar Front. J. Phys. Ocean., v. 11, p. 780-793.

Toole, J.M. and D.T. Georgi (1981). On the dynamics and effects of double-diffusively driven intrusions. Prog. Ocean., v. 10, p. 123-145.

Turner, J.S. and H. Stommel (1964). A new case of convection in the presence of combined vertical salinity and temperature gradients. Proc. Nat. Acad. Sci. USA, v. 52, p. 49-53.

Turner, J.S. (1965). The coupled turbulent transports of salt and heat across a sharp density interface. Int. J. Heat Mass Transfer, v. 8, p. 759-767.

Turner, J.S. (1967). Salt fingers across a density interface. Deep-Sea Res., v. 14. p. 599-611.

Turner, J.S. (1968). The behaviour of a stable salinity gradient heated from below. J. Fluid Mech., v. 33, p. 183-200.

Turner, J.S. (1973). Buoyancy effects in fluids. Cambridge University Press, Cambridge (UK), p. 251-287.

Turner, J.S. (1974). Double-diffusive phenomena. Ann. Rev. Fluid Mech., v. 6, p. 37-56.

Turner, J.S. (1978). Double-diffusive intrusions into a density gradient. J. Geophys. Res., v. 83, p. 2887-2901.

Turner, J.S. (1979). Laboratory models of double diffusive processes in the ocean, In: National Academy of Sciences. Twelfth Symposium on Naval Hydrodynamics, National Academy of Sciences, Washington, D.C., p. 596-606.

Turner, J.S. (1985). Multicomponent convection. Ann. Rev. Fluid Mech., v. 17, p. 11-44.

Turner, J.S. and C.F. Chen (1974). Two-dimensional effects in double-diffusive convection. J. Fluid Mech., v. 63, p. 577-592.

Varma, K.K. and L.V. Gangadhara Rao (1978). Observations on fine structure in the northern Arabian Sea. Indian Journal of Marine Sciences, v. 7, p. 79-83.

Veronis, G. (1965). On finite-amplitude instability in thermohaline convection. J. Mar. Res., v. 23, p. 1-17.

Veronis, G. (1968). Effect of a stabilizing gradient of solute on thermal convection. J. Fluid Mech., v. 34, p. 315-336.

Voorhis, A.D. and D.L. Dorson (1975). Thermal convection in the ATLANTIS II hot brine pool. Deep-Sea Res., v. 22, p. 176-175.

Voorhis, A.D., D.C. Webb, and R.S. Millard (1976). Current structure and mixing in the shelf/slope water front south of New England. J. Geophys. Res., v. 81, p. 3695-3708.

Walin, G. (1964). Note on the stability of water stratified by both salt and heat. Tellus, v. 16, p. 389-393.

Walton, I.C. (1982). Double-diffusive convection with large variable gradients. J. Fluid Mech., v. 125. p. 123-135.

Weinburger, H. (1964). The physics of the solar pond. Solar Energy, v. 8, p. 45-56.

Wiesenburg, D.A. (1980). Geochemistry of dissolved gases in the hypersaline Orca Basin. PhD dissertation, Texas A and M University, College Station, TX., 265 p.

Williams, A.J. (1974). Salt fingers observed in the Mediterranean outflow. Science, v. 185, p. 941-943.

Williams, A. J. (1975). Images of ocean microstructure. Deep-Sea Res., v. 22, p. 811-829.

Williams, III, Albert J. (1981). The role of double diffusion in a Gulf Stream Frontal Intrusion. J. Geophys. Res., v. 86, p. 1917-1928.

Wilson, A.T. and H.W. Wellman (1962). Lake Vanda: an Antarctic Lake. Nature, v. 196, p. 1171.

Worthem, S., E. Mollo-Christensen, and F. Ostapoff (1983). Effects of rotation and shear on doubly diffusive instability. J. Fluid Mech., v. 133, p. 297-319.

Zangrando, F. (1979). Observation and analysis of a full-scale experimental salt gradient solar pond. PhD dissertation, University of New Mexico, Albuquerque, NM, 131 p.

Zeman, O. and J.L. Lumley (1983). Progress in modeling multi-layer salt-fingering structures. Mathematical Modelling, v. 4, p. 73-85.

Zeman, O. and J.L. Lumley (1982). Modeling salt-fingering structures. J. Mar. Res., v. 40, p. 315-330.

Zenk, W. (1970). On the temperature and salinity of the Mediterranean water in the north-east Atlantic. Deep-Sea Res., v. 17. p. 627-632.

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